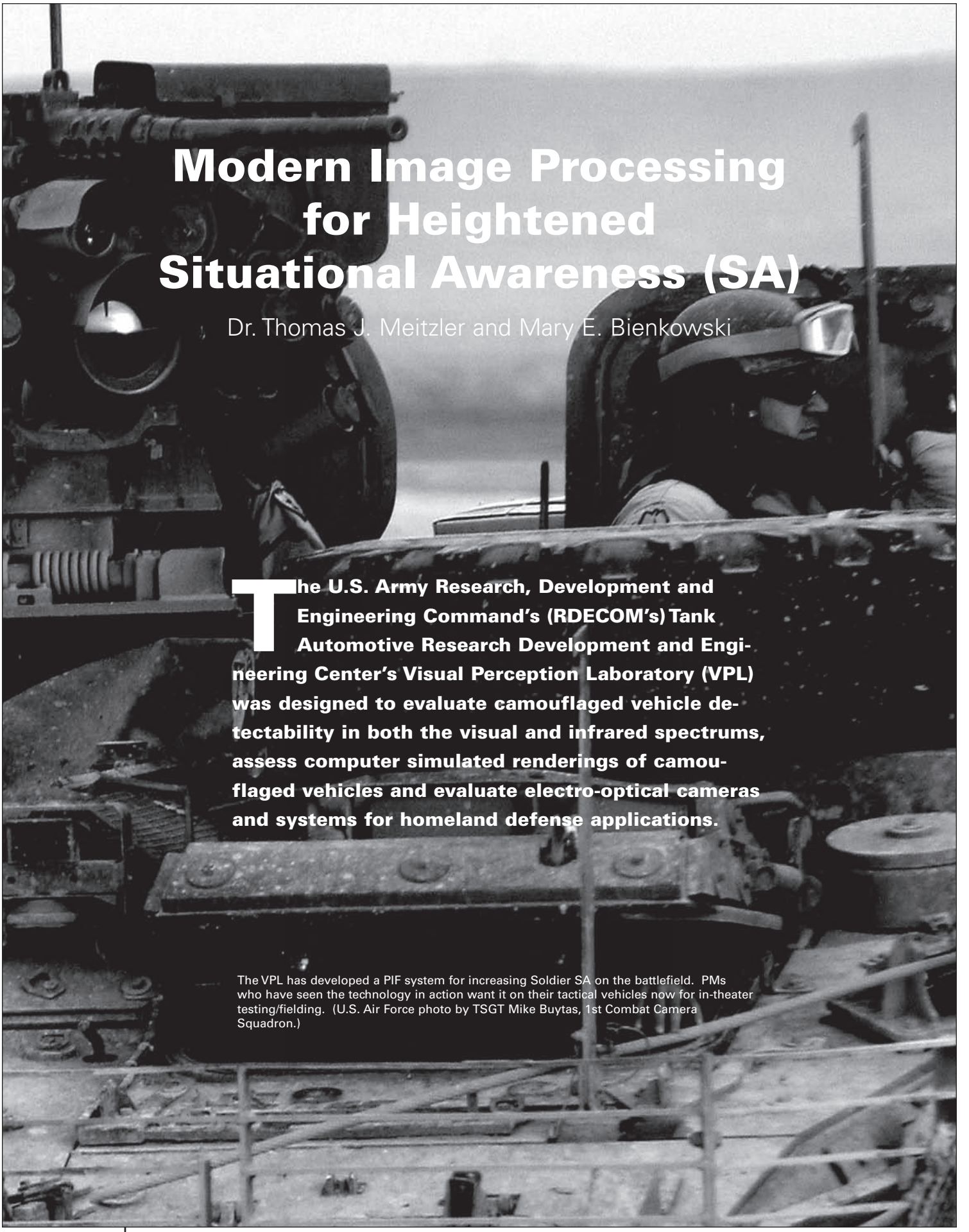
Modern Image Processing for Heightened Situational Awareness (SA)

Dr. Thomas J. Meitzler and Mary E. Bienkowski



The U.S. Army Research, Development and Engineering Command's (RDECOM's) Tank Automotive Research Development and Engineering Center's Visual Perception Laboratory (VPL) was designed to evaluate camouflaged vehicle detectability in both the visual and infrared spectrums, assess computer simulated renderings of camouflaged vehicles and evaluate electro-optical cameras and systems for homeland defense applications.

The VPL has developed a PIF system for increasing Soldier SA on the battlefield. PMs who have seen the technology in action want it on their tactical vehicles now for in-theater testing/fielding. (U.S. Air Force photo by TSGT Mike Buytas, 1st Combat Camera Squadron.)

Modern image fusion technologies will allow the U.S. military to achieve the surveillance, security and detection applications needed for 21st century warfare and security operations. When combining information extracted from multiple sources, the fused result will provide more details, resulting in superior battlefield SA.

The VPL is actively working with various homeland security liaisons to locate programs to develop and apply these technologies. Potential applications of image fusion and 3-D displays for homeland defense are listed below.

- Concealed weapon and mine detection using sensor fusion and edge enhancement along with passive infrared and/or millimeter-wave (mm-wave) multiband imagery.
- Close-proximity wraparound fusion vision system for airplane passenger terrorist identification.
- Surveillance vehicle with wraparound enhanced vision and concealed weapon detection for peacekeeping operations in urban environments.
- Aerial unmanned robotic surveillance.
- Mm-wave using passive sensors to detect hidden objects — no irradiation of subject.
- Integration of 3-D visual images and mm-wave to increase visibility and image clarity.
- 3-D display technology for use at existing airport search stations, or imbedded in walls. The technology unobtrusively scans passengers and other airport personnel.

The same algorithms that are used for fusion of multiband imagery for mine detection can also be used for concealed weapon detection. Fuzzy-based image fusion can now be used to segment image areas that may show concealed weapons. The VPL has been working with Wayne State University and Ethereal Technology in Ann Arbor, MI, to apply autostereoscopic technology and image fusion to the problems associated with detecting people carrying weapons, 3-D baggage inspection at airports and crowd surveillance at large public facilities. An important attribute of the VPL autostereoscopic display is that it is not dependent on users wearing goggles or glasses. Likewise, the display renders a high-resolution image. A 3-D image is formed by the brain fusing a left and right image as it does from the left and right eye. Using image fusion in concert with 3-D displays can potentially improve concealed object detection.

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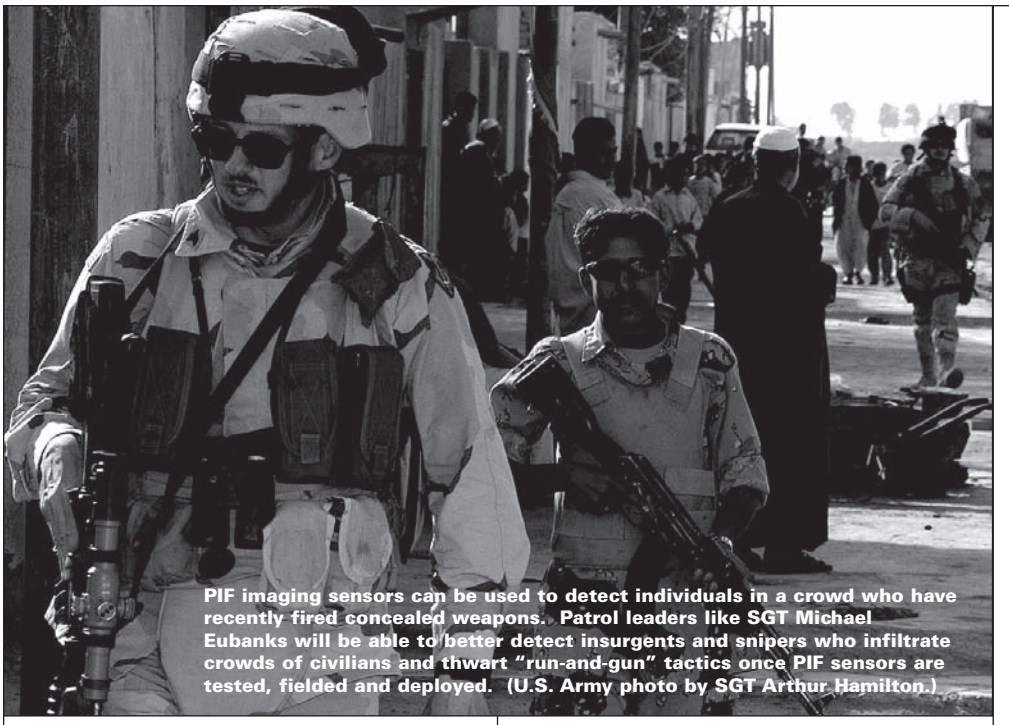
3-D Display and Stereoscopic Imagery

With current elevated security concerns, VPL engineers investigated using 3-D displays to increase the throughput scanning efficiency and accuracy of detection of concealed explosive devices in packages. A new prototype 3-D display can project 3-D images from a stereoscopic pair of images. A pair of X-ray images are obtained from a conventional X-ray scanner similar to the one used at the Tank-automotive and Armaments Command receiving dock, and can be presented in 3-D to observers without the use of special viewing goggles.

It has been estimated that failures in advanced man-machine systems can be attributed to "human error" and may be as high as 75 percent. Increasingly, operator error is a result of SA loss. Therefore, 3-D displays can increase SA by allowing screeners to see information collected by sensors in a natural environment as opposed to planar images. There are numerous mirror systems that form a real 3-D image in space of an object in a position that is well separated from the object. A major part of the stereoscopic display used in the VPL is the spherical concave mirror. A spherical mirror can magnify the size of the object being displayed.

The VPL team and Ford laboratories are testing and beginning the technology insertion of PIF vision systems for peacekeeping operations and homeland defense. (Photo courtesy of RBG-RDECOM.)



PIF imaging sensors can be used to detect individuals in a crowd who have recently fired concealed weapons. Patrol leaders like SGT Michael Eubanks will be able to better detect insurgents and snipers who infiltrate crowds of civilians and thwart "run-and-gun" tactics once PIF sensors are tested, fielded and deployed. (U.S. Army photo by SGT Arthur Hamilton.)

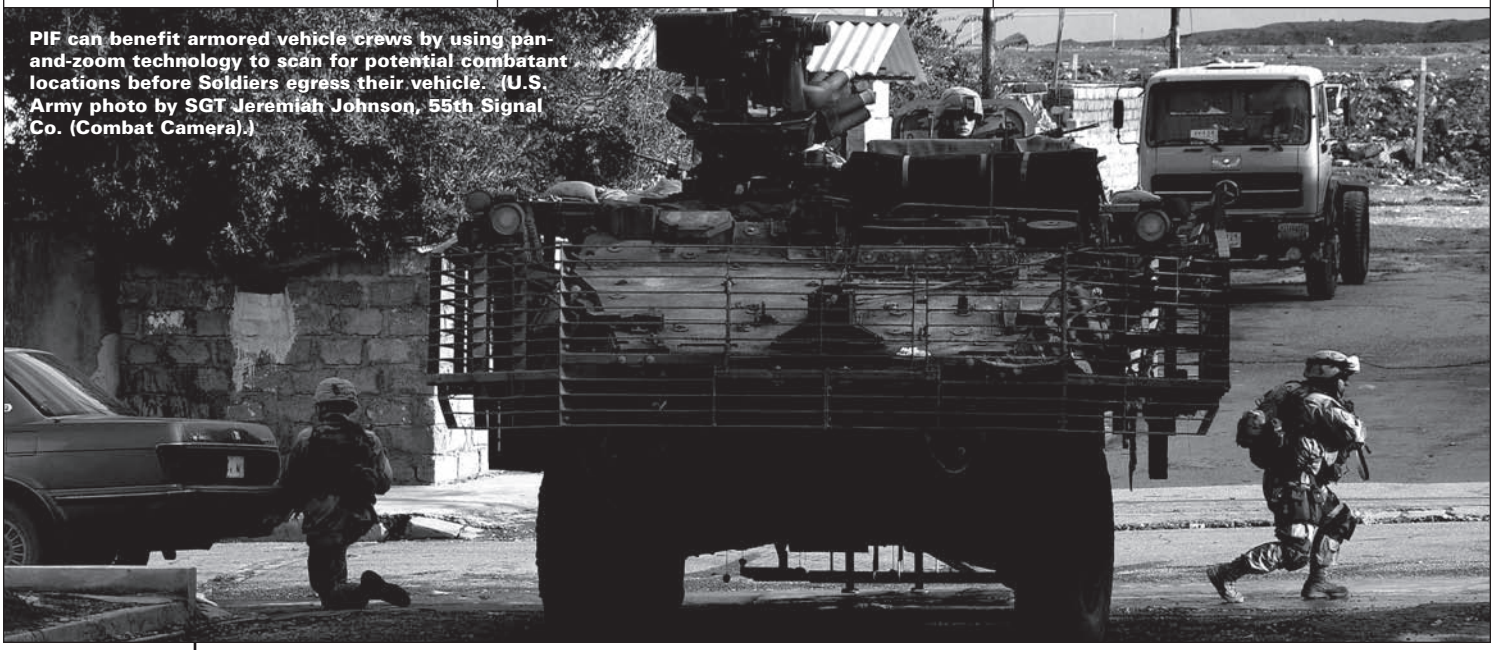
There is a need for technology to scan packages and use this 3-D system to reduce illegal weapons transport and potential threats on U.S. soil. This display can be applied to crowd surveillance and screening at public access points as well. During times of increased security and the threat of passengers carrying concealed weapons or other harmful items, sensor fusion and 3-D displays could be of benefit in alerting guards to potentially dangerous passengers. Combining sensor fusion with 3-D displays could also improve the recognition rates by guards using cameras that scan crowds for people who are listed in known terrorist databases. We believe that implementing volumetric visible and infrared (IR) images will improve the recognition rate because it will provide a more detailed 3-D image — or thermal properties — versus a 2-D visible image.

Panoramic Image Fusion (PIF) System

The VPL team and Ford Laboratories are testing and beginning the technology insertion of a PIF vision system. This system's applications include peacekeeping operations in Afghanistan and Iraq, homeland defense, border surveillance, early warning passive detection of threats and medical telepresence. The vision system is mounted on the front and rear of the vehicle and provides day and night panoramic imaging by fusing the visible and IR video from multiple cameras in real time. The system uses commercial-off-the-shelf video cameras and imaging boards. By combining imaging sensor fusion capabilities with panoramic vision, the vehicle occupants have 360-degree SA.

Why is more than one type of sensor required? Because IR cameras give increased night-vision capability and visible sensors are of little use at night or in poorly lit areas. Even in well-lit areas, night-vision technology provides a safety benefit by making it easier to detect camouflaged insurgents. In daylight, PIF can be used to detect individuals in a crowd who have recently fired their weapons. This is due to the heat generated by the weapons as seen through clothes by the imaging sensors.

PIF's benefit to an armored vehicle's crew is that it provides SA prior to vehicle egress. Soldiers in a closed vehicle



PIF can benefit armored vehicle crews by using pan-and-zoom technology to scan for potential combatant locations before Soldiers egress their vehicle. (U.S. Army photo by SGT Jeremiah Johnson, 55th Signal Co. (Combat Camera).)

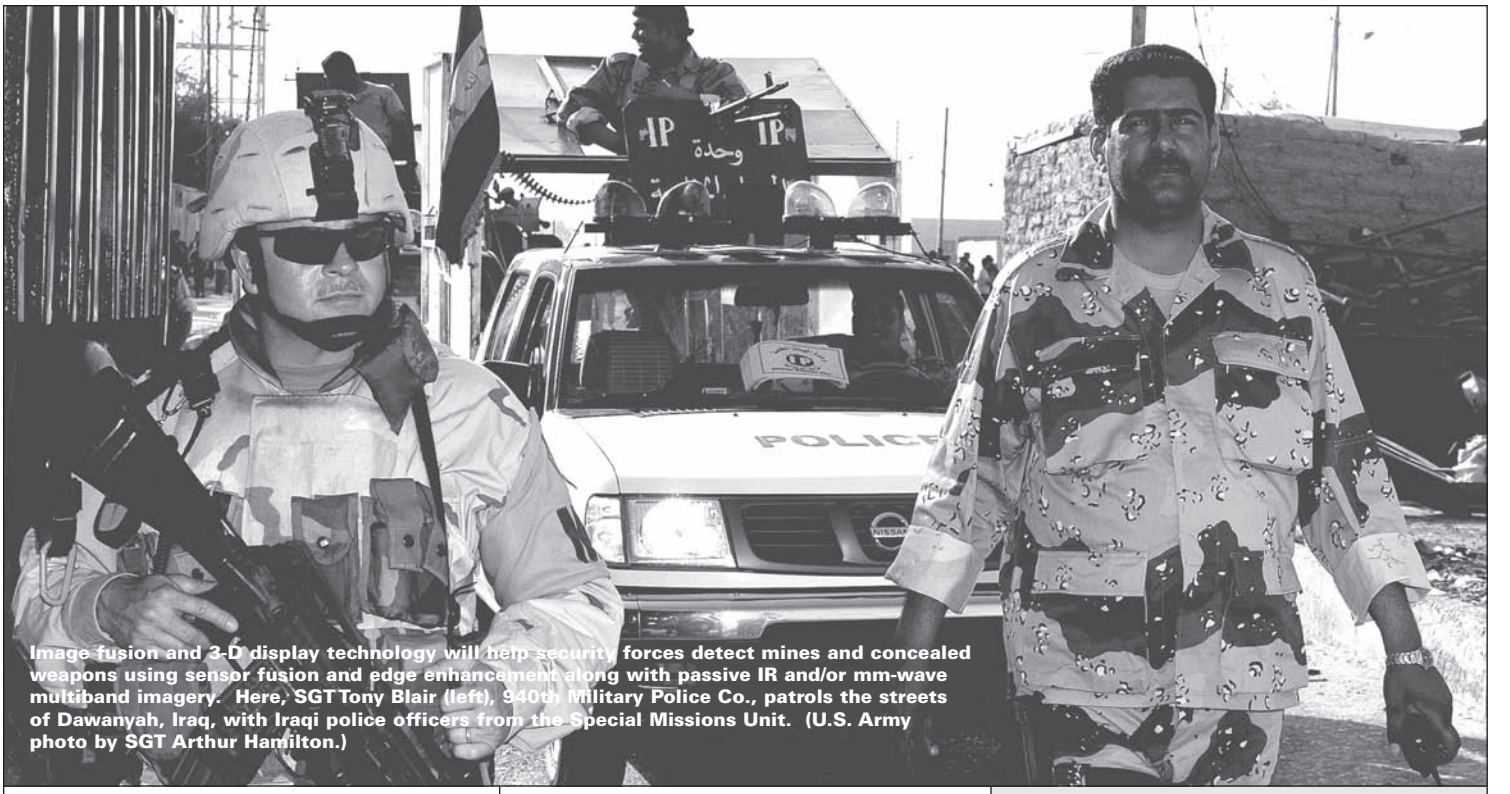


Image fusion and 3-D display technology will help security forces detect mines and concealed weapons using sensor fusion and edge enhancement along with passive IR and/or mm-wave multiband imagery. Here, SGT Tony Blair (left), 940th Military Police Co., patrols the streets of Dawanyah, Iraq, with Iraqi police officers from the Special Missions Unit. (U.S. Army photo by SGT Arthur Hamilton.)

can use this technology to pan and zoom around the vehicle's vicinity and learn of potential combatants' locations. The major advantage is that the scene can be interpreted much more quickly and accurately, thereby increasing Soldier survivability and responsiveness.

VPL Status

In FY04, VPL geared its research to homeland defense and the global war on terrorism and was featured on a local television broadcast. The segment discussed the PIF system being developed for tactical vehicles, as well as a novel 3-D imaging technology that could be used to scan crowds at entrances to public structures. The VPL was also highlighted on the History Channel's recent "Stealth on Land" series. The use of the lab for camouflage assessment was described and showed how a Soldier takes a camouflaged vehicle perception test in the VPL.

As mentioned in the key research areas above, the VPL has developed a PIF system for increasing the SA of Soldiers in Iraq and Afghanistan and National Guardsmen and law enforcement officers at home. This technology has been shown to Program Manager (PM) Stryker, PM Light Assault Vehicle, PM Tactical Vehicle and PM Heavy Equipment Transport. Those PMs who have seen the technology want it on their vehicles for in-theater testing. The biggest problem at this time is securing funding to supply our customers fleets of vehicles.

Maintaining SA, dynamic surveillance and target development is important for our Soldiers. In the near future, this task will be accomplished through image sensor acquisition, data fusion and 3-D visualization. The implementation of the integrated image system will support real-time SA for homeland defense by providing images of vehicles with IR signatures.

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MARY E. BIENKOWSKI is a VPL Mechanical Engineer for the RBG Survivability Team, RDECOM. She received her B.S. in mechanical engineering and is pursuing her M.S. in engineering management, both from Oakland University in Rochester, MI. She is Level II certified in SPRDE. Her most recent research development involves image fusion, camera response testing and threat assessment through stereoscopic imagery for ongoing homeland security collaboration.